Space Technology Research Grants

Mission Design and Orbit Maintenance Strategies in the Earth-Moon System

Completed Technology Project (2011 - 2015)

Project Introduction

The successes of India's Chandrayaan probe and NASA's Lunar Reconnaissance Orbiter have generated a renewed interest in the lunar surface. And, while a number of missions such as ISEE-3, MAP, and Genesis have exploited the region near the Sun-Earth libration points, no spacecraft had ever reached and remained in the vicinity of an Earth-Moon libration point until the ARTEMIS mission successfully inserted into an Earth-Moon L2 orbit in August of 2010. Given the continued success of the ARTEMIS probes and the potential future uses of libration point orbits as platforms for communication and scientific activities, it seems likely that interest in Earth-Moon libration point orbits will only continue to increase. To best meet future mission requirements in this regime, efficient, strategies algorithms coupled with a better overall understanding of this complicated dynamical environment are required. Continuing innovation in this area is critical to achieving NASA's future goals in the Earth-Moon system in the areas of space science, communication and exploration. Given the chaotic, dynamically sensitive nature of the Earth-Moon problem, flexible and robust numerical algorithms are critical to mission design and orbit maintenance strategies. Due to the unstable nature of most libration point orbits in this system, numerically integrated trajectory segments will eventually depart the intended orbit. The period of the current orbits of interest are approximately two weeks, thus, stationkeeping maneuvers are required every one to two weeks to maintain the spacecraft in the vicinity of the Earth-Moon libration points. Current strategies typically target an orbit condition one to two revolutions in the future and it is possible that a maneuver may create undesirable changes in the orbit at a later time. The use of multiple trajectory segments, however, delivers a differential corrections process to efficiently and effectively design a maneuver that targets the entire remaining path along the planned trajectory. This global-type approach ensures that planned maneuvers do not disrupt the remaining trajectory arcs or negatively impact the end-of-mission goals (lunar arrival conditions, for example). Design strategies and algorithms will also be developed to systematically explore the most productive modification of a highly sensitive trajectory in the Earth-Moon system due to planned or unplanned events. For example, the ARTEMIS mission has demonstrated that the evolution of the out-of-plane amplitude of an Earth-Moon libration orbit can evolve in dramatically different ways in the presence of even small errors in position and/or velocity. The current remedy in response to this problem involves manual testing of various maneuver locations and magnitudes. However, modifying a corrections algorithm used previously to study Earth-Moon transfer trajectories, delta-V maneuvers can be inserted at locations along the trajectory automatically and a type of Monte Carlo analysis completed. The total delta-V cost can then be lowered and, in doing so, the most efficient maneuver location(s) become more apparent. This process is straightforward but extremely nontrivial in such a numerically sensitive regime. This same procedure is also applicable in altering lunar arrival conditions or coordinating the rendezvous of two spacecraft in separate

Project Image Mission Design and Orbit Maintenance Strategies in the Earth-Moon System

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

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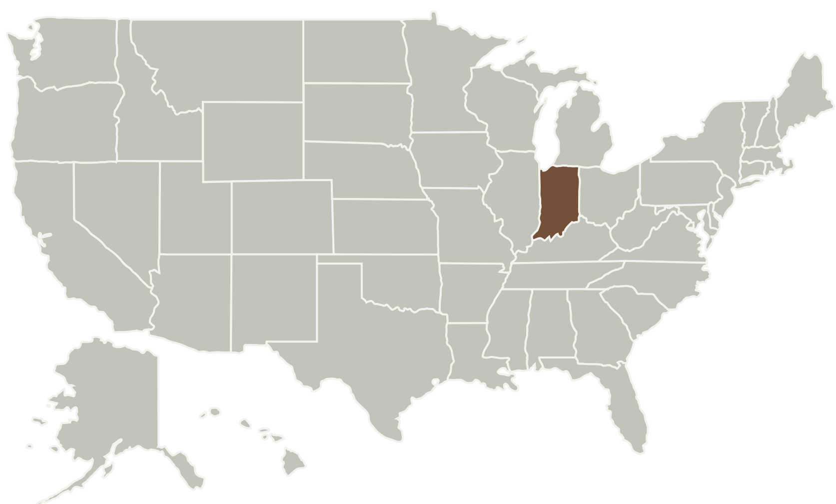
libration point orbits.

Anticipated Benefits

Given the continued success of the ARTEMIS probes and the potential future uses of libration point orbits as platforms for communication and scientific activities, it seems likely that interest in Earth-Moon libration point orbits will only continue to increase. To best meet future mission requirements in this regime, efficient, strategies algorithms coupled with a better overall understanding of this complicated dynamical environment are required. Continuing innovation in this area is critical to achieving NASA's future goals in the Earth-Moon system in the areas of space science, communication and exploration.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Purdue University-Main Campus	Supporting Organization	Academia	West Lafayette, Indiana

Primary U.S. Work Locations
Indiana

Project Management

Program Director:
Claudia M Meyer

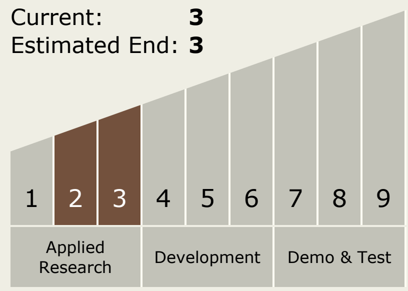
Program Manager:
Hung D Nguyen

Principal Investigator:
Kathleen M Howell

Co-Investigator:
Thomas A Pavlak

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX17 Guidance, Navigation, and Control (GN&C)
  └ TX17.2 Navigation Technologies
    └ TX17.2.6 Rendezvous, Proximity Operations, and Capture Trajectory Design and Orbit Determination

Images

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Project Image Mission Design and Orbit Maintenance Strategies in the Earth-Moon System
(https://techport.nasa.gov/image/1793)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html